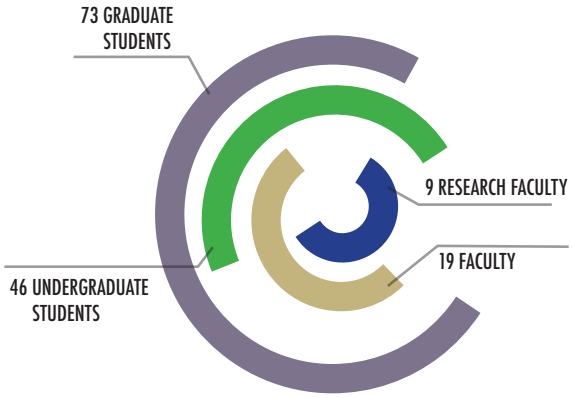
Colorado Center for Astrodynamics Research
UNIVERSITY OF COLORADO BOULDER

The Colorado Center for Astrodynamics Research (CCAR)

is dedicated to the study of astrodynamics and the application of satellites to science, navigation, and remote sensing of the Earth and planets. Hosted by the Ann and H.J. Smead Department of Aerospace Engineering Sciences in the College of Engineering and Applied Sciences, CCAR was established in 1985 as a key component of the University of Colorado at Boulder's emphasis on space science. CCAR brings together a multidisciplinary group of faculty, staff, and students to enhance our understanding of the Earth and the solar system through satellite missions and observations. Research emphasis areas include astrodynamics, which involves orbital and attitude motion of Earth satellites, interplanetary spacecraft, and planetary bodies; global navigation satellite systems (GNSS) used for orbit determination, remote sensing, and vehicle navigation, and remote sensing of the Earth's surface, gravity field, oceans, atmosphere and space.



RECENT HIGHLIGHTS

Dr. Hanspeter Schaub has been selected to receive the 2018 American Institute of Aeronautics and Astronautics Mechanics and Control of Flight Award.

Dr. Steve Nerem has been appointed to the National Academies of Science, Engineering, and Medicine's Committee on Earth Sciences and Applications from Space.

Professor Dennis Akos received a grant for GPS/GNSS Receiver Development for Remote Sensing.

Dr. Bob Marshall's proposal, "Magnetic Cubesat Constellation for Advanced Navigational Models," was selected for funding in the Grand Challenge 2017 competition.

Dr. Steve Nerem received funding for his proposal entitled "Using Satellite Measurements to Improve Regional Estimates of the Impacts of Sea Level Change."

Dr. Jeff Thayer & Dan Baker had their proposal, "Space Weather Technology, Research and Education Center," chosen for funding in the Grand Challenge 2017 competition.

Dr. Penny Axelrad is one of two recipients of the 2017 Excellence in Leadership Award, given to an alumnus of the systemwide Excellence in Leadership Program.

RESEARCH PARTNERS

NSF
NASA
Air Force Office of Scientific Research and Research lab
a.i.solutions, Inc.
ASTRA, LLC
Ball Aerospace & Technologies
Blue Canyon Technologies
Broad Reach Engineering
Department of Education
Department of Transportation
DigitalGlobe, Inc.
Federal Aviation Administration
Geoptics
Jet Propulsion Lab
Lockheed Martin
Naval Research Labs
NOAA
Numerica Corporation
Office of Naval Research
Science Applications International Corporation
Univeristy of Montpellier
Southwest Research Institute
University of Maryland
Auburn University

CCAR CENTER DIRECTORS

Jeff Thayer | CCAR Director, received his PhD in atmospheric and space science from the University of Michigan in 1990. Prior to arriving at CU in 2004, Dr. Thayer was a research physicist at SRI International and most notably principal investigator of a national upper atmosphere observatory in Greenland. Dr. Thayer has over 28 years of experience leading research in the near-space environment, advancing remote sensing technologies, developing strategic plans for NASA and NSF, and publishing over 110+ journal articles. To advance understanding of the near-space environment's impact on space assets, he studies geophysical fluid dynamics, gas-plasma interactions, and electrodynamics using ground and space-based observations along with theoretical modeling. He has received several teaching and research awards from the College of Engineering and Applied Sciences and the University. He is a senior member of the American Institute of Aeronautics and Astronautics, American Geophysical Union, and Optical Society of America.

R. Steven Nerem | CCAR Associate Director, received his PhD in aerospace engineering from the University of Texas at Austin in 1989. He worked for NASA's Goddard Space Flight Center as a geophysicist and then with the University of Texas at Austin as an associate professor.
Nerem is a specialist in satellite orbit determination, satellite remote sensing, and space geodesy who has participated in several NASA flight projects, including Lageos II, TOPEX/Poseidon, Jason-1, and GRACE. In 1995, he was awarded NASA's Exceptional Scientific Achievement Medal for his research in the area of gravity field determination. He won AGU's Geodesy Award in 2006 and was elected a Fellow of AGU in 2008. Nerem was selected as a Lead Author for the U.N.'s Intergovernmental Panel on Climate Change (IPCC) Working Group I 5th Assessment Report (AR5) in 2013. He is also a fellow of CU's Cooperative Institute for Research in Environmental Sciences.

FACULTY

Dennis Akos | *Professor*
Software radio technology, satellite navigation systems, RF signal processing, RF interference detection and localization.

Penina Axelrad | *Professor*
Global Positioning System (GPS) technology and applications for real-time satellite orbit and attitude determination, GPS surface reflections, GPS multipath characterization and mitigation, orbital dynamics and spacecraft rendezvous.

Natasha Bosanac | *Asst Professor*
Spacecraft trajectory design and optimization, celestial mechanics, dynamical systems theory, multi-body systems, small satellites and formations and swarms.

Robert Braun | *Professor*
Astrodynamics; Hypersonics; Entry, Descent and Landing; Space Technology.

Robert Culp | *Emeritus - Professor*
Space debris, satellite fragmentation modeling, hazard to resident space objects, and the space environment.

William Emery | *Emeritus - Professor*
Ocean surface processes such as sea surface temperature, ocean color, surface currents, coastal satellite altimetry.

Lakshmi Kantha | *Professor*
Numerical models of the oceans and related physical processes. Assimilation of remotely sensed data into numerical ocean models, nowcasting, and short-term forecasting of the ocean state; circulation in marginal and coastal bodies of water.

Delores Knipp | *Professor - Research*
Atmospheric and space physics, upper atmosphere electrodynamics, plasma physics, satellite drag, space weather as a system.

Kristine Larson | *Professor*
Applications of GPS, including navigation, positioning, orbit determination, seismology, volcano monitoring, soil moisture, snow depth, and vegetation sensing.

Robert Marshall | *Asst Professor*
Remote sensing and in situ studies of the atmosphere, ionosphere, and magnetosphere using optical, low-frequency radio, and energetic electron measurements; plasma physics; numerical simulations; observations and modeling of lightning and meteors.

Tomoko Matsuo | *Asst Professor*
Data assimilation and inverse methods, their applications to remote sensing and in-situ data of the atmosphere and geospace; Atmospheric and space physics; Spatial statistics; Estimation theory; and Dynamical systems theory.

Jay McMahon | *Asst Professor*
Astrodynamics, aerospace vehicle guidance, navigation and control; asteroid and comet science; ISRU.

Yu (Jade) Morton | *Professor*
Global Navigation Satellite Systems (GNSS) receiver technology for navigation in challenging environments and for remote sensing of the ionosphere, atmosphere, and Earth's surface.

R. Steven Nerem | *Professor*
Satellite altimetry, sea level change, Earth gravity field determination, time variations of the Earth's gravity field, planetary geodesy, precision orbit determination, astrodynamics.

RESEARCH FACILITIES

Lightning, Atmosphere, Ionosphere and Radiation Belt Research Group
Satellite Radar Altimeter Calibration Site in Santa Barbara Bay
Boulder Atmospheere and Space Instrumentation Laboratory
Radar and Lidar Installations in the Arctic and Antarctic
Celestial and Spaceflight Mechanics Laboratory
Small Satellite Test and Integration Laboratory
Commercial Spaceflight Operations Laboratory
Satellite Guidance and Control Laboratory
Active Remote Sensing Laboratory
Exoplanets Research Lab
Imaging Laboratories
ORCCA Laboratory
GNSS Laboratory

Scott Palo | *Professor*
Design, construction, deployment and operation of HF/VHF meteor radar systems, statistical detection, estimation, and direction of arrival algorithms, atmospheric remote sensing, global nonlinear atmospheric dynamics and sampling/aliasing issues related to asynoptic satellite sampling.

Hanspeter Schaub | *Professor*
Nonlinear dynamics and control, astrodynamics, rigid body kinematics and dynamics, variable speed control moment gyroscopes, spacecraft formation flying, proximity flying using visual control, electrostatic actuation of spacecraft nodes and components.

Daniel Scheeres | *Professor*
Investigation of orbital dynamics of highly perturbed systems using analytical, semi-analytical, and numerical methods.

Jeffrey Thayer | *Professor*
Remote sensing of the atmosphere and ionosphere using lidar and radar techniques; optical systems and design; atmospheric and space physics; geophysical fluid dynamics, electrodynamics, and plasma physics.

Christopher Williams | *Professor*
Ground, airborne, and satellite radars to study precipitation microphysics and cloud dynamics.

PROFESSIONAL RESEARCH ASSOCIATES

Harrison Bourne | *Professional Research Associate*
High accuracy estimation of ionosphere total electron content (TEC) using global navigation satellite system (GNSS) signals and on develop robust GNSS signal recording systems for deployment around the world

Liam Kilcommons | *Professional Research Associate*
Space weather, sun-earth system science, satellite data products and standards

Steve Taylor | *Professional Research Associate*
Building and deploying global navigation satellite system (GNSS) data collection systems and developing real-time GNSS monitoring applications

Jun Wang | *Professional Research Associate*
Time-frequency analysis of GNSS scintillation signals and GNSS receiver signal processing

RESEARCH ASSOCIATES

Sandra Castro | *Senior Research Associate*
Remotely sensed sea surface temperatures and air sea interaction

Diego Paul Sanchez Lana | *Senior Research Associate*
Granular flows in asteroids, pattern formation in granular media, grain-fluid interaction in granular media and avalanche formation

Mark Tschudi | *Senior Research Associate*
Remote sensing of Arctic sea ice, Sea ice surface evolution during summer melt and trends in Arctic sea ice extent and volume.

Kathryn Davis | *Research Associate*
The three-body problem, interplanetary trajectory design and dynamical systems theory.

Carolyn Roesler | *Research Associate*
High-Frequency Radar Coastal Currents to Correct Satellite Altimetry

Wiebke Deirling | *Research Associate*
Global electric circuit, atmospheric electricity, lightning, radar meteorology and cloud physics.

Nagaraj Shivaramaiah | *Research Associate*
GNSS Receivers, FPGA-SoC System Design, Signal Processing for Navigation Alternative Positioning and Navigation

Rong Yang | *Research Associate*
Signal processing techniques for atmospheric remote sensing application in challenging environments

Wei Xu | *Research Associate*
Energetic radiation from lightning/ thunderstorms, plasma physics and atmospheric electrodynamics electron pecipitation from radiation belt

POSTDOCTORAL RESEARCHERS

Chih-Ting Hsu | *Postdoctoral Researcher*
COSMIC observations from into a numerical model of the Earth's upper atmosphere

Austin Sousa | *Postdoctoral Researcher*
Netural and anthropogenic electrical processes in the space environment, with an emphasis on instrumentation and remote sensing

STAFF

Sarah Melssen | *Professional Research Manager*
Samantha Stires | *Professional Research Associate*
Steve Hart | *IT Systems Administrator*